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A Comparison of Isometric and Isotonic Exercises as Methods of Building Strength

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A COMPARISON OF ISOMETRIC AND ISOTONIC EXERCISES AS METHODS OF BUILDING STRENGTH

A Thesis

Presented to

the Graduate Faculty

Central Washington State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Education

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CHAPTER I

THE PROBLEM AND ITS SCOPE

Although it has only recently begun to gain favorable recognition in the United States, weight lifting in various forms is one of the most ancient of physical activities. Other "basic sports" are competition in running, jumping, throwing, swimming, and wrestling. These activities are the ones that develop physical characteristics always considered desirable through necessity: strength, speed, agility, and hardiness (18:4).

An investigation of the training routines followed by some of the leading athletes of the world, indicates that they believe strength to be essential to whatever sport they engage in and they have specific programs for building strength.

> Coaches and competing athletes know that a skilled man with strength always has an advantage over a man who depends on skill alone. In addition, it is easier for a strong man to develop endurance and learn to move effectively because his muscles have the surplus strength to carry him through the necessary tasks required of them (18:5).

World record discus throwing champion, Jay Silvester, follows a training program which includes vigorous weight lifting. He uses weight training faithfully and feels that it is a big factor in the success he has had with the discus (12).

Vern Wolfe, University of Southern California track coach, firmly believes that weight lifting is a good method by which to gain strength, and that strength is essential for good performance in track and field. Wolfe has coached or is coaching such outstanding stars as Dallas Long, shot put record holder, Jim Brewer, 16' pole vaulter, and Karl Johnston, discus thrower (27).

Gary Gubner, another outstanding shot putter, stresses the importance of a rigorous weight lifting program in his over-all shot put training. Gary is 6' 2 1/2" tall and weighs 270 pounds; almost all of it is useful muscle. He competed in the Maccabiah Games in Tel Aviv and brought back three gold medals--in the shot put, the discus, and in weight lifting. Except for the discus, he could duplicate this performance in Tokyo in the 1964 Olympics (13:31).

Bob Hoffman, who owns most of the barbells in the world, and who is an authority on lifting, sees a bright future for Gary Gubner in weight lifting (13:31).

Modern athletes, in search of new world records, turn to weight-training as an aid to greater strength and improved stamina for, as has often been said, normal training is no longer enough to bring about the high standards demanded in sports and athletics today (17:5).

Weight lifting is a form of isotonic exercise (18:35). For this study, isotonic exercises will mean the same as weight lifting or weight training involving the use of barbells.

Some of the modern day athletes have substituted isometric training programs for the isotonic type of strength-building. Bob Avant, high jumper for the University of Southern California, used isometric tension for strength building (27). Glenn Passey, Skyline discus champion, uses a combination of isotonic and isometric training for building strength (12).

Max Howell and W. R. Morford, advocates of isometric exercises for strength building, have claimed the following advantages of this type of training over the use of isotonic methods (9:1):

1. Isometric training requires less time. No more than five minutes would be needed to exercise most of the larger muscle groups of the body. The exercises can be done at any time of the day--at home, in a physical education class period, in a locker room, or in an outdoor setting. For an athlete they can be done either before or after practice or in any other free time.

2. The program requires little or no equipment.

3. The fatigue factor can be avoided, as a single contraction held for six seconds at two-thirds maximum effort does not lead to fatigue.

4. Heart and circulation are not stressed in isometric training.

Dr. Karpovich, whose isotonic training (weight lifting) program will be discussed later in this study, has made the following comment concerning isometric training:

> It is hard to accept these reports, because they apparently contradict every-day experience. Just think about musclemen working one to two hours a day for at least three days a week in order to develop strength. Maybe they are just wasting their time. Maybe! (10:36)

Isometric exercises consist of muscle contractions which allow no shortening or lengthening of the muscle fibers during the contraction period.

The Problem

Statement of the problem. In view of today's emphasis on the need for physical strength, and the concern of the leaders of the Physical Education progression for greater physical fitness of our youth, the author felt more research should be conducted which might indicate ways of building strength. It was the purpose of this study to compare the results of selected isotonic exercises (weight lifting) with selected isometric exercises against a control group as means of building strength.

Analysis of the problem. The isometric and isotonic exercises selected for use in this study were determined after an extensive

review of literature. The data obtained from the results of the experiments conducted for this study is used as a basis for measuring the differences that may exist between isometric and isotonic exercises as used for strength building purposes.

Basic Assumptions

It was assumed that all of the subjects participating in the experiment would participate in approximately the same amount of physical activity outside of school hours during the eight-week period of this study and that any differences in the average changes in strength of the three groups (isometric, isotonic, control) was due to the exercise programs assigned to each.

This study proceeded on the assumption that strength can be developed by selected isotonic and by selected isometric exercises.

It was assumed that resulting differences in strength can be effectively measured by the Roger's Strength Test (26:179).

It was assumed that an eight-week training period would allow sufficient time to evaluate the effectiveness of the two types of exercise programs.

Definition of Terms Used

Isometric contractions. A type of exercise which allows no shortening or lengthening of the muscle fibers during the contraction

period.

Isotonic contractions. A type of exercise which allows the muscle fibers to lengthen and shorten during the contraction period.

Isometric group. A group of thirteen senior Great Falls High School male students who performed prescribed isometric exercises over an eight-week period, five times per week.

Isotonic group. A group of eleven senior Great Falls High School male students who performed prescribed isotonic exercises consisting of weight lifting over an eight-week period, three times per week.

Control group. A group of eleven senior Great Falls High School male students who volunteered to take the Roger's Strength Test before and after the eight-week training period.

Strength Index - (S. I.). The gross score obtained from the six strength tests plus lung capacity test of the Roger's Strength Test (26:179-190) which is proposed as a measure of strength of the large voluntary muscles of the body.

Limitations of the Study

This experiment was limited to thirty-five senior male students of Great Falls High School who were not engaged in any type of formal physical activities or athletic programs.

The students participating in the experiment were divided into three groups of approximately equal number. One group of eleven performed the selected isotonic exercises; another group of thirteen did selected isometric exercises; and the third group, or control group, of eleven participated in no formal physical education activities or organized athletic programs during the period between the initial and final strength tests.

This study was limited to an eight-week exercise period with the isotonic group doing selected weight lifting exercises three days a week and the isometric group participating in selected isometric exercises five days per week.

Evaluation of results was based upon the differences or changes noted in the performance levels of the individual experimental subjects as indicated by the composite scores of the Roger's Strength Test. The test was administered before the training program started, and again at the conclusion of the eight-week training program.

The study was further limited to comparisons of the changes in muscular strength, as indicated by the Roger's Strength Test Indexes, to determine whether or not there was statistically significant differences in these changes among the isotonic, isometric and control groups at the .01 level of confidence.

Need for the Study

For many years man has engaged in running, jumping and throwing objects and in a combination of these activities. Essentially these inherent and very natural activities have been incorporated into the modern day athletic games, especially in track and field. Especially since the revival of interest in amateur athletics, dating from the middle of the nineteenth century, athletes and coaches have striven to improve techniques of the sport in which they are involved. Unlike many discoverers of new or improved processes in the world of business and commerce, the coaches and athletes who developed more efficient techniques and procedures have generously shared their findings with fellow coaches and athletes and others who were interested. Many books, magazine articles, monographs, and theses have been written on the various aspects of athletics to increase the knowledge of all phases of athletics (1:19).

However, only a beginning has been made; much investigation and reporting still needs to be done. Among those phases in which there was apparently a void in literature, were studies involving the comparison of different strength building programs. More and more emphasis is being placed on strength as a basis for all-round good athletic performance, as is indicated by the review of literature.

Studies have been made of the effect of isotonic training and of isometric exercises to increase muscle strength, but a review of literature did not disclose a study that compared the two methods as a means of gaining strength.

The author felt there was a need for research to determine the relative effect of the two methods of exercise for building strength in high school male students. As strength is a component of physical fitness, and both isotonic and isometric strength building programs have proven their value in previous studies, an effort has been made in this study to ascertain which method of training would produce the greater gain in muscle strength in a limited period of time.

Summary

This chapter has attempted to point out the need for efficient strength-building programs in our present society, and the interest displayed in such programs by leaders in the Physical Education profession. Interest in methods of building strength has been indicated by reference to some of the leading athletes of today and their use of strength-building programs in their over-all training programs.

CHAPTER II

SURVEY OF RELATED LITERATURE

Introduction

Muscular strength underlies all of our daily activities. Therefore, strength building programs, as well as strength testing, become important to the teacher concerned with the development of this strength if he is to effectively accomplish his work. Strength testing is not a modern technique, nor are strength building programs new. Cureton cites evidence of strength testing as early as 1702, by De la Hire and Aontons (3:358).

The names of three experimenters, Morpurgo, Siebert and Muller, mark the road that has brought us to our present knowledge of the anatomy and physiology of strength. Their work has yielded findings and conclusions that are essential to an understanding of strength and its development (24:147).

In 1897, Professor B. Morpugo, of the Pathological Institute of the University of Siena, wrote as follows:

> As certain as is the fact that the mass of voluntary muscles increases in response to greater work, so uncertain is our knowledge concerning the mechanism that underlies this enlargement. There is no lack of assertions in the literature that deal with this subject in more or less decisive fashion and interpret the activity-hypertrophy as

either a true hypertrophy in the sense of Virchow or as a combination of hyperplasia and hypertrophy; but exhaustive proof is everywhere lacking (24:147).

Murray and Karpovich describe muscles as follows:

Our muscles are made up of small, thread-like muscel fibers. The fibers vary from 1/25 to 1 1/2 inches in length and from 1/250 to 1/2500 inch in thickness. To form a big muscle, these fibers are arranged in bundles that extend in a chain-like fashion from one end of the muscle to the other. Each fiber and each bundle is wrapped in connective tissue, which is thin in flabby muscles and thick and tough in strong muscles. These wrappings are connected to each other, and at the ends of muscles they are fused with tendons, which in turn are attached to the bones. It has been estimated that there are about two hundred and fifty million muscle fibers in the body!

In training for strength, muscles increase in size much more than in training for endurance, because strength depend on the cross-section of muscle fibers, and endurance on the addition of capillaries around the fibers. Although the size of muscles increases with exercise, the number of fibers remains the same. Obviously, then, each fiber has to become larger. And that is what actually happens.

The rate at which muscles grow depends on the individual differences and on the type and intensity of training. Although nothing can be done about individual differences with which man is endowed when he is born, the type and intensity of training can be controlled and adjusted to the individual. Though there is no unanimous agreement regarding the details of training, there is one agreement in principle: If you want to develop strength, use the overload method (18:34-38).

Selection of Isotonic Exercises

The word isotonic means having, or indicating, equal tones, or tension, as defined by Webster's New Collegiate Dictionary (25:448).

Isotonic weight training programs involving the use of barbells and similar equipment have been followed by athletes and those who wishes to increase their strength through the ages. Many professional football players, wrestlers, competitive swimmers, and most of the nationally and internationally famous throwers of the discus, the javelin, the hammer, and the shot have improved their competitive performances by the inclusion of regular and specific programs of weight training in their preparation for competition. Many of these athletes have become regional, national, or world champions, and a considerable number of them have established world records in their events (6:12-64).

Steve Seymour was America's number one javelin thrower before World War II. He won National AAU titles in 1947, 1948, and 1950. His American record, set in Lincoln, Nebraska, in 1947, made even the superb Finnish athletes look up. The following year he proved this throw was no fluke by winning the silver medal at the Olympic Games in London.

Seymour at one time or another has experimented with almost every form of training and physical exercise. He became one of the

first track men to experiment with weight lifting. He now believes it important that a weight thrower should strengthen his entire body, not merely his throwing arm. Seymour constantly experiments with new techniques, and believes the potential of weight lifting in training for other sports has yet to be fully realized (22:35).

One year--that's the time it took Dallas Long to develop from just a good high school shot putter into the second greatest in American and world competition. One year--and weight training!

Many of the leading shot, discus and weight-throw men, like the great Parry O'Brien, Fortune Gordien, Harold Connolly, Bob Backus and Bill Neider, recently had been making amazing progress. And all had pointed to training with barbells and dumbbells as a chief reason for their improvement.

Pole-vaulter Bob Richards, half-miler Mal Whitfield, hurdler and decathlon champ Milt Campbell, sprinter, broad-jumper and hurdler Mike Herman are just a few track and field stars who use weight training.

In baseball, Ralph Kiner and Jackie Jensen of the Boston Red Sox are among the many power-hitters who have strengthened themselves by training with weights. And pitcher Bob Feller, the finest fast-baller of our time, worked out regularly with dumbbells, barbells and pulley-weights.

Line and backfield stars such as Stan Jones, Alan Ameche and Steve Van Buren are representative of the many gridiron stars who built themselves up with weight training.

Wilt Chamberlain, who has to be among anybody's top ten modern basketball stars, has worked out with weights for years, which may have a lot to do not only with his muscular build but with his jumping power, co-ordination, and stamina (5:3-5).

The correlation between strength and hitting and throwing in baseball was investigated by Gene Hooks of Wake Forest University. He concluded that shoulder strength is a neglected area in baseball. After having taken a test for hitting and throwing for distance, before and after a weight lifting program, the players showed remarkable improvement in both hitting and throwing, even though baseball was not practiced for the six weeks the weight lifting was in effect (8:32).

Sidney Calvin undertook a study to investigate the effect of a program of progressive resistive exercises in the form of weight training on the motor coordination of high school boys. At the conclusion of the experimental period, a statistical analysis of the data indicated that the experimental group improved in motor coordination more significantly than did the control group. This increase in motor

coordination was apparently associated with increased anthropometrical and strength measurements caused by the progressive resistive exercise program (2:425).

The average physical education teacher or athletic coach will have little, if any, interest in turning out the rippling-muscled specimens who compete in best-developed-man events. He will, however, often have students who need special attention to gain strength, or team prospects who would perform more efficiently by the simple addition of strength. The basic exercises described by Murray and Karpovich, and used for this study, are not new or different from movements weight-trained men have been practicing for decades, but they do solve the problem of adding strength and increasing the size of all the body's muscles, and, therefore, have their part in a physical conditioning program.

The system of progression is simple. It is one in which the muscles are trained to do more and more work gradually. Gains in both strength and muscle size are relatively rapid at the start and slower after progress has been made (18:71-73).

Selection of Isometric Exercises

The word isometric, as defined by Webster, means of, pertaining to, or indicating equality of measure (25:448). A muscle contracts

isometrically when it exerts force against an immovable resistance. Under such conditions, the muscle remains at the same length, i.e., no shortening of the muscle fibers occur. In the performance of regular exercises, as in calisthenics and weight training, shortening and lengthening of the muscle occurs.

Research has been carried out in the past few years on the effects of static or isometric training for developing strength and muscular endurance. The results of some of these experiments are summarized here (9:1).

1. A single static contraction a day at 2/3 maximal strength will result in as maximum an increase in strength as other known methods of training involving greater resistance and more frequent contractions (14:111-126).

2. A series of six-second contractions of the Commander Set variety (described in Appendix A) performed three times a week resulted in gains in muscular endurance that were equal to results obtained by weight training three times a week (4).

3. Strength training appears to be specific. An increase in strength acquired by means of standing forearm flexion resistance exercise is not apparent when the forearm is flexed with the body in an unfamiliar position (20:29).

4. Strength gained rapidly by concentrated training over a short period of time is lost equally quickly upon cessation of training (16:453). Evidence is available to show that there is greater strength retention when training is spaced over a longer period of time (15:217), or when the frequency of contractions per training period is increased (11:330).

Sports Illustrated devoted four pages to isometric contractions as a method of building strength in the October 30, 1961, issue. Gilbert Rogin described the enthusiasm shown by some of our outstanding athletes toward isometric training:

> The Notre Dame football team does it enthusiastically. The San Francisco 49er's do it shyly. The Pittsburgh Pirates do it. Overweight girls in Baton Rouge do it. Star athletes like Bob Avant and basketball player Bob Pettit do it and weight lifters like Louis Reicke and Bill March swear by it (21:19).

Lou Rieck had been lifting weights for fourteen years with little success. He stopped weight training and began a set of isometric exercises for a mere fifteen minutes a day, including rest periods. At the end of six months, he was able to press 330 pounds, 45 pounds more than his previous high. At the age of 34 he earned a berth on the five-man U. S. Olympic weight-lifting team (21:20).

Norbert Roy, co-captain of the Notre Dame football team, brought isometric contractions up the river from his native Baton Rouge, introduced them informally to his teammates. Dozens of factors contributed

to Notre Dame's markedly low injury rate that year. Isometric contractions might well have been one of them. The same low injury rate was seen on the Pirates and the 49ers, where isometric contractions are used extensively (21:20).

Professor Gene Logan of the University of Southern California, where high jumper Bob Avant was a student, reckoned that the angle of the knee of Avant's push-off leg was 135° at the moment of takeoff and decided to strengthen his leg muscles at that precise angle. Logan built what he calls "the device". Avant inserts his right leg in it and pulls with all his might. He considers this isometric contraction the most important factor in converting himself from a 6-foot-8 high jumper to a 7-footer. It took two months (21:20).

Bob Pettit, star forward for the St. Louis Hawks, worked with isometric contractions for six weeks last summer and became measurably stronger, as indicated by weight-lifting feats. Pettit and Roy did their isometric training in Baton Rouge, which is no coincidence: the Louisiana capitol is a hotbed of the system. Francis Drury, a Louisiana State physical education professor, was one of its earliest advocates, as was Trainer Marty Broussard, who has developed special isometric contraction equipment for LSU sprinters and football players. Broussard says he has even used isometric contractions to improve

his golf game. Holding a club in various positions against immovable objects and straining the muscles employed at those points, he has lengthened his drives 15 yards. Dr. Drury and Alvin Roy, Norbert's uncle and the proprietor of a Baton Rouge health studio, predicted that through isometric contraction all world records in weight lifting will be this year, every world track and field record broken within the next year (21:20).

Wesley K. Ruff, associate professor of Physical Education at Stanford, says isometric contractions can be helpful to the person without room or facilities for exercise (e.g., space travelers, long-distance drivers, deskbound office workers). It can improve all-around fitness, provided it is used along with exercises like running, which build up the cardiovascular and respiratory systems. And it can be helpful to people who have all the natural skills of their favorite sport but lack the needed strength (21:21).

Rarick and Larsen conducted a study to compare the effectiveness of a single daily six-second isometric bout using two-thirds maximum tension, with another exercise program involving more frequent exercise bouts at 80% maximum tension (19:333). The results generally supported the findings of Hettinger and Muller (14:111-126), in that brief periods of isometric tension (one six-second bout daily at two-thirds

maximum tension) proved to be as effective for strength development as more frequently repeated exercise bouts at higher levels of tension. However, the latter method was found to be somewhat superior in terms of strength retention.

The strength of muscles is adapted to needs by muscular growth. The stimulus for increasing muscle strength is not fatigue, but the force exerted during the job. When this force exceeds one-third of maximum strength, the maximum speed of increase in strength is reached with one single, short duration static contraction per day. With one single, short duration contraction per week the rate is one-third of this maximum. Loss of strength after training by daily contraction is at the rate at which it was gained. The slower increase by weekly training leads to a more permanent acquisition of strength (16:512).

A set of thirteen isometric exercises, aimed at general strength building, was prepared by Dr. Arthur H. Steinhaus in collaboration with the late Commander Charles D. Giauque, USNR (23:40). These exercises were used by the author in the experimental exercise program for this study and are described in Appendix A.

Methods of Performing Isotonic Exercises

It has been found that better results are gained from weight

training if the exercise is not practiced daily. Time is needed for the building of muscles and if the exercise periods follow too closely, one after another, the time may not be sufficient. For the person who is underweight or weak, it is very important that no physical activity of any consequence be undertaken on the "off" days. For a person of normal health and strength, however, other activities on non-weight training days should have no adverse effect (18:75).

A set of twelve basic resistance exercises described by Murray and Karpovich were used for this study. These exercises are described in Appendix A (18:75-82).

Methods of Performing Isometric Exercises

The fact that persistent use of muscles causes their enlargement and a correlated increase in their strength has been known ever since there were boys, and finally found its way into Greek mythology. But only the most careful researchers of the past 57 years have revealed the nature and limitations of this increase, the kind of exercise that brings it about, and the laws that govern its development (23:147-150).

Isometric contraction is, in fact, neither new nor revoluntionary, but only recently has it been widely applied to a variety of sports. Arthur Steinhaus notes that scientists in the early 1920's conducted

experiments in which one leg of a frog was tied down while the other was left free. The muscle in the tied-down leg grew significantly (21:21).

Steinhaus contends that you don't have to do repetitive exercises to build muscle, but he says athletes have been taught to suffer, and any system that makes it easy seems wrong to them (21).

Karpovich recognizes isometric contraction as a valuable system for rehabilitating the handicapped. Indeed, it has been used to maintain and rebuild the strength of hospitalized and convalescent patients. Dr. W. T. Liberson, in a controlled study at a veteran's hospital in Rocky Hill, Connecticut, reported strength increases of up to 300% through the application of isometric contraction (21).

Steinhaus prescribes thirteen isometric exercises for use in general strength building. The author decided to use this group for this study, and a description of these exercises can be seen in Appendix A (23:40).

Selection of Test Exercises

The place and importance of measurement in health and physical education are well established in today's modern programs. There are available several excellent texts in this area which provide such information as historical background, purposes and scope, general

administrative procedures, critical evaluations of available tests, test construction principles, and statistical techniques for the organization and interpretation of test results (26).

Good testing programs consume time, usually time taken from already crowded programs of activity. The use of this valuable time is justified only when the testing is carried out in order to achieve some worthy purpose in line with sound educational principles.

Plans for testing should stem from the needs of the program and of the participants in the program. These two needs are inextricably interwoven. The individuals' needs become the basis for the program. These needs are pinpointed and expressed through stated program objectives. It is in the attainment of these objectives that plans for testing should be rooted. As an example, the organic needs of persons are expressed through the physical fitness objective in physical education. It is a worthy purpose to test a group of persons at the start of a program in order to ascertain their physical fitness needs (26:9). Such testing was used by the author to attempt to determine the Strength Index, as measured by the Roger's Strength Test, of the individual subjects participating in the experiment.

The author hoped to determine the growth of strength of the individual experimental subjects during an eight-week exercise period

by comparison of the scores of the initial testing program as against those of the final testing program administered at the end of the experimental training period.

The purpose of the Roger's Strength Test is to determine the Strength Index (SI), which indicates the strength of the large voluntary muscles of the body and is used as a measure of general athletic ability. It may be used to classify individuals into homogeneous groups (26:179).

Analysis of the Data

The data derived from the results of the initial Roger's Strength Test administered to the experimental subjects was used to divide the subjects into three homogenous groups. The procedure used for this grouping of subjects is explained in further detail in Chapter III.

The data derived from the results of the final Roger's Strength Test administered at the end of the eight-week training period was used to measure the amount of change in strength of the subjects as compared to the results of the initial testing program.

Standard statistical procedures were used for the analysis of data in this study. The critical ratio technique was the primary method used, and the .01 level of confidence was the minimum standard for acceptance of whether a difference between the groups was real or due to chance. These procedures will be further explained in Chapter III.

Summary

In Chapter II, the author has cited representatives of various sports who have employed either, or both, isotonic and isometric exercises in their training programs. Also, related literature concerning research in the two methods has been cited.

A brief outline has been sketched of the methods of selecting the exercises used in the experiment conducted in conjunction with this study, and of the selection of the methods of performance of same.

Chapter III will be devoted, for the main part, to a description of the experiment itself--the methods employed in selection of subjects, the equipment involved, the training tactics and an analysis of the exercise program and its results.

CHAPTER III

PROCEDURE OF THE STUDY

Selection of the Test Items

This study was concerned with determining the growth of strength through selected isotonic and isometric exercises, and with a comparison of the growth of strength of the two groups using these types of exercises as well as with a comparison of each of these two groups with a control group which did not follow an exercise program.

The Strength Index for each student participating in the experiment was determined by use of the six test items within the Roger's Strength Test. These items are listed below, and are described in further detail with instructions for administration in Appendix A.

1. Leg strength
2. Back strength
3. Lung capacity
4. Grip strength
5. Chinning
6. Dipping

Faculty members who aided in the administration of the tests were chosen from the coaching and physical education staff of Great

Falls High School. Information sheets and directions for their completion, and administration of the test were issued to the faculty members who were to conduct the testing. A pre-test conference was held, and each test item was discussed. Each faculty member helping with the administration of the testing program was given a pre-trial test run, in order to familiarize these assistants with the test items and the scoring procedures. The author supervised the over-all testing program, and gave help to his associates when it was needed. (A copy of the instructions can be found in Appendix A.)

In tabulating the statistics, Pearson's linear product-moment method of correlation, as outlined by Henry E. Garrett, was used (7:139-140).

After a review of literature, in which various published tests of strength testing were examined, it was determined by the author that the Roger's Strength Test was best suited to the experimental program related to this study.

Isotonic Exercises

Karpovich and Murray's prescribed exercises for general strength building were used for the isotonic group. As fatigue is a factor in weight training, Karpovich and Murray suggest that three bouts

per week with the weights are sufficient, and this suggestion was followed by the author (18:72-83).

The twelve basic exercises, including a suggested warm-up, as prescribed by Karpovich and Murray, are described in detail in Appendix A, along with instructions for each. They consist of: (1) Warm-up; (2) Curl; (3) Press; (4) Rowing; (5) Squat; (6) Pullover; (7) Rise-on-toes; (8) Dead lift; (9) Upright rowing; (10) Press on bench; (11) Bent-arm lateral raise, lying; (12) Lateral raise, standing (18:75-83).

Isometric Exercises

Steinhaus prescribes thirteen isometric exercises for general strength building (23:40). As fatigue is not a factor in isometric training, it was decided by the author that the exercises would be performed by the experimental subjects five times a week.

These exercises are described in detail, with instructions for performance of each in Appendix A, and are as follows: (1) The elbow push; (2) The hand push; (3) The reach; (4) The muscle-maker; (5) The twist; (6) The grip; (7) The finger stretch; (8) The front flattener; (9) The curver; (10) The spread; (11) The squat; (12) The heel stand; (13) The arch raiser.

Selection of Equipment

The training program for the isometric exercises involved no need for special equipment. This aspect is one of the main assets of isometric training.

The equipment necessary for the performance of isotonic exercises (weight lifting, for the purpose of this study) consisted of a standard set of bar bells, which were available through the physical education department of Great Falls High School where this experiment was conducted. The bar bells were adjustable in weight to accommodate the varied strength capacity of each individual experimental subject.

The equipment used to test the various degrees of strength of the experimental subjects, as measured by the Roger's Strength Test, were as follows: (1) for leg strength and back strength, a leg and back dynamometer; (2) for lung capacity, a wet spirometer; (3) for grip strength, a hand monumometer; (4) for chinning, a chinning bar; and (5) for dipping, the parallel bars.

Selection of Subjects

The subjects who participated in the strength testing experiment consisted of senior, male Great Falls High School students not otherwise involved in any type of organized physical education program, or

organized athletic program, during the period between the initial and final strength tests. Forty-five students originally volunteered for the experiment, but due to absences, illnesses and lack of interest, thirty-five actually participated.

Method of Division into Sub-Groups

The original forty-five volunteers were divided into three equated groups of fifteen each, which consisted of the isotonic group, the isometric group, and the control group. Of these subjects, four from the isotonic group, two from the isometric group, and four from the control group, failed to complete the program.

When the Roger's Strength Test had been administered to the entire group of Great Falls High School students participating in the experiment, at the beginning of the experimental period, these test scores, with the numbers assigned to the students who made each score, were listed on a data card, a specimen of which has been placed in Appendix B, with the highest score listed first, and the remaining scores following in their order of rank.

In selecting the sub-group which was assigned to isometric training, the boys with the highest score and the boys with the fourth highest, seventh highest, and those with each third ranks below the seventh, were chosen.

To make up the sub-group which followed the program of isotonic training, the boys who ranked second, fifth, and each subsequent third ranks below, were selected.

The control group was made up of those boys whose scores placed them in order of ranks which were divisible by three.

Separate data cards were then made, listing the names of the boys and original scores made in the Roger's Strength Test for each of the isometric group, the isotonic group and the control group.

As more data was gathered following the second administration of the Roger's Strength Test at the conclusion of the eight weeks training period, the final score made by each subject was entered on the data card for the group to which he was assigned, together with the number of scores which indicated his improvement (or loss) in strength during the period of study.

The information on the data cards for the three groups provided the information needed for the comparative studies made of the effect of the types of training in which the groups had engaged during the eight week period.

Initial Test

The Roger's Strength Test administered at the beginning of the training program was conducted in the Great Falls High School

gymnasium. Figure 1 in Appendix B shows the layout of stations as employed for group testing procedures. The subjects started at Station 1 and moved from one test to the next, following the order suggested by Weiss and Phillips (26:180), and indicated in Figure 1 in Appendix B. The order of testing was from the least to the most strenuous, with no deviation from this pattern.

Isotonic Sub-Group Training

The system of progression in isotonic training (or weight lifting for the purpose of this study) is simple. It is one in which the muscles are trained to do more and more work gradually (18:72).

It has been found that better results are gained from weight training if the exercise is not practiced daily. Time is needed for the building of muscles and if the exercise periods follow too closely, the time may not be sufficient. It is suggested by Murray and Karpovich that exercising should be practiced only every other day, or three alternating days per week (18:72), and this suggestion was followed by the author. The subjects included in the isotonic Sub-group met at the Great Falls High School gymnasium every Sunday, Tuesday and Thursday at 7:00 p. m. , during the eight week training period. The author supervised each training session.

Each subject experimented to determine how much weight he could use to perform a given exercise eight repetitions without stopping at the first weight training session. In subsequent sessions, when twelve repetitions were reached, 5 to 10 pounds were added to the bar bell and the number of repetitions were dropped back to eight to begin the same number of first repetitions and then weight (18:74). Each training session lasted approximately two hours.

This was a program of gradually increasing severity, so as to make injury or overwork almost impossible.

Isometric Sub-Group Training

Steinhaus, in his suggested list of thirteen basic isometric exercises and their performance, indicates that since fatigue is not a factor in isometric training, these exercises can be performed daily without undue strain. In conjunction with this indication, the author met with the isometric group each school day, or five times a week.

The isometric group performed the prescribed exercises at 8:00 a. m. in the gymnasium of the Great Falls High School. The training sessions lasted approximately 10 to 15 minutes. Each of the thirteen exercises were performed daily at maximum tension, six seconds each.

Psychological Considerations

The students involved in the experiment were oriented as to the purpose of the program and the tests that were to be given. A great amount of interest was displayed by the boys who were involved in the weight training program, but some doubt was shown by those selected for the isometric training program. The doubt seemed to echo Karpovich's statement that strength should not be gained through such short exercise period (10:36). However, the attitudes of both the isometric and isotonic groups improved as the program progressed, and as they felt they were gaining in strength. The author encouraged this attitude whenever possible, in order to obtain maximum efforts of participation from the students.

Final Test

The Roger's Strength Test administered at the end of the training followed the same pattern as that given at the beginning of the program.

Analysis of the Data

In the comparison of the test results, the following steps were carried out: the author first determined the means of the differences between the initial and final tests of each of the three groups. The standard deviation of each of the groups and the standard error of the

difference between the means was calculated. The critical ratio between the observed difference between the means and the standard error of the difference was computed and evaluated in terms of the .01 level of confidence in order to determine whether the existing difference between the groups was real or perhaps due to chance.

On the basis of the evidence revealed, the author sought to compare isometric exercises with isotonic exercises as a means of building strength. This comparison was based on standard statistical procedures (7:139-140).

Summary

The author has endeavored, in Chapter III, to outline the procedures employed in the development of this study. Equipment used in the testing program as well as the training program has been described. The method of selecting the subjects, and their subsequent division into homogeneous groups has been explained. The methods of training involved in the two exercise groups has been described. The psychological aspects and the attitudes of the subjects toward the experimental procedures were mentioned. Statistical procedures used have been briefly outlined, as based on the initial and final test results.

In Chapter IV, the author will report in further detail, the findings based on the results of the study.

CHAPTER IV

FINDINGS OF THE STUDY

Introduction

In order to determine the change in strength resulting from the training programs used in this study, and to compare these changes, standard statistical procedures were employed by the author.

In the comparison of the changes in strength among the isometric group, the isotonic group, and the control group (which participated in no training program), during the eight week training period, the formula employed for finding the standard error of the difference between the means was one used when means are not correlated. In this study, since samples were small, N-1, rather than N, was used to compute all standard deviations.

Statistical Procedures

The mean of the scores in the Roger's Strength Index made by each group before the training period began, and the mean of the scores in the same test administered at the conclusion of the training period by each group, were found.

The coefficient of linear correlation of the scores made in the initial and in the final test by each group was computed by the ungrouped

scores method when deviations were taken from the means. The standard errors of the initial and final means and the standard error of the difference between the means in the initial and the final Roger's Strength Test were computed. Using this data, the difference between the means was tested for significance at the .01 level of confidence. In the computations, the formula for finding the standard error of the difference of correlated means was used.

The mean and the standard deviation of increases in strength as indicated by the differences in the scores made in the initial and final Roger's Strength Test by the three groups were found. The standard error of this mean was computed.

Isotonic Group

The mean gain for the isotonic group between the initial and final Roger's Strength Test Index was 327 points. The standard error of the difference between the two means was 60.6. The coefficient of the correlation between the two means was .90, with the standard error of correlation being .216. The critical ratio was 6.11, which is significant at the .01 level of confidence.

Isometric Group

The mean gain between the initial and final Roger's Strength Test

Index for the Isometric group was 407. 4 points. The standard error of the difference between the two means was 50. 84. The coefficient of the correlation between the two means was . 86, with the standard error of correlation being . 076. The critical ratio of this group was 4. 49, which is significant at the . 01 level of confidence.

Control Group

The mean gain for the Control group between the initial and final Roger's Strength Test Index was 86. 73 points. The standard error of difference between the two means was 29. 75. The coefficient of the correlation between the two means was . 219, with the standard error of correlation being . 083. The critical ratio of the Control group was 1. 87, which is not significant. (See Table I, Page 39)

Comparison of Isotonic Group with Isometric Group

The standard error of the difference of the mean gain in scores made by the Isotonic Group and by the Isometric Group was computed using the formula for the standard error of the difference in uncorrelated means, and the actual difference in the mean gains in scores by the two groups tested for significance.

The mean gain for the Isotonic Group was 327 points, as compared to the mean gain for the Isometric Group of 407. 38. The standard

FIGURE 1

GROWTH CHART

	Isotonic Group	Isometric Group	Control Group
Mean Gain of the Two Means	327	407.4	86.73
Standard Error of the Difference of the Two Means	60.6	50.84	29.75
Coefficient of Correlation Between the Two Means	.90	.86	.219
Standard Error of Correlation	.216	.076	.083
Critical Ratio	6.11	4.49	1.87
Level of Confidence	.01	.01	Not Significant
Mean Per Cent Gain	13%	16%	3.4%

error of the difference between the two means of the Isotonic Group was 60.6 as compared to 50.84 for the Isometric Group. The critical ratio was 1.01, which is not significant.

Comparison of Isotonic Group with Control Group

The standard error of the mean differences in gains in the Roger's Strength Test Index made by the Isotonic Group and by the Control Group, was computed and compared with the actual difference in the gains in strength made by the two groups to ascertain whether or not there was a statistically significant difference. The critical ratio was 3.56, which is significant at the .01 level of confidence.

Comparison of Isometric Group with Control Group

To compare the gains in strength as indicated by the difference in scores in the Roger's Strength Test Index made by the Isometric Group with the gains in strength made by the Control Group, the standard error of the difference of the means of the gains made by these two groups was computed to test the significance of the difference between the two means. The critical ratio was 5.45, which is significant at the .01 level of confidence. (See Table II, Page 41)

Percentages of Gains in All Groups

The mean percentage of gain within the Isometric Group was 16%; within the Isotonic Group, 13%; within the Control Group, 3.4%. These figures indicate that both the Isometric and Isotonic methods of training were of significant value in building strength.

FIGURE 2

COMPARISON CHART

	Comparison of Isotonic with Isometric	Comparison of Isotonic with Control	Comparison of Isometric with Control
Critical Ratio	1.01	3.56	5.45
Level of Confidence	Not Significant	.01	.01

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

Lack of time devoted to physical activity in the United States in this modern day has led to some concern for the physical fitness of our citizens. As strength is one of the basic components for physical fitness, and isometric training is a short cut to strength in regard to equipment and time element, the author felt that research was needed to determine the feasibility of certain strength building programs.

The purpose of this study was to determine whether isometric and isotonic exercises would build strength, and to compare these two exercise programs. By review of literature, the author sought to uncover studies that would support the hypothesis that strength can be gained through isometric contractions as well as by isotonic, or weight lifting, exercises. This study proceeded on this assumption.

Summary

In analyzing the improvements in the Roger's Strength Index made in the eight weeks by the groups engaged in the isotonic training and the isometric training, it was apparent that there was no statistically significant difference shown by the Great Falls High School students

comprising the two groups. The isotonic group had an average improvement of 327 points in the Roger's Strength Index, and the isometric group's average improvement was 407 points. The standard error of the difference of the two means was 79.1. The actual difference of the gains made in the Roger's Strength Index by the isometric group over the isotonic group was 80.4 points. The critical ratio found in order to determine whether or not the isometric group's larger gains were reliable was 1.01, which is clearly not significant.

Conclusions

In the final analysis it was found that the male students, as represented by Great Falls High School in both the isometric and isotonic groups, gained in strength. As compared to the control group, both groups showed significantly greater growth in strength in the eight week training period. This study indicates from the analysis of the data that both isometric and isotonic exercises, if used diligently, will add to a high school student's Strength Index, as measured by the Roger's Strength Test.

It is the belief of the author that the Roger's Strength Test is an adequate test for this study and would certainly measure changes which have occurred during the training period. The growth in strength shown

by the groups participating in the training programs indicates there is a definite advantage in following either of the exercise programs as outlined in this study.

On the basis of the evidence shown by the study, the hypothesis of the author, that strength can be gained through isometric exercises, can be supported.

Recommendations

The author recommends that more study is needed, and suggests that further research be conducted, using only isotonic and isometric groups, since the control group cannot be controlled adequately in their outside activities, as is shown by the slight gain in strength made by the control group used in this study. Larger numbers of subjects within the groups would provide a more reliable basis for the resulting conclusions.

It is also recommended that the training programs, in conjunction with this research, be conducted over a number of years so that the number of participants may be increased. It is possible to conduct this same type of study at various grade levels.

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APPENDIX A

APPENDIX A

The basic isotonic exercises prescribed by Murray and Karpovich and used in this study are as follows:

1. Warm-up. Stand close to a barbell that is well within your strength ability to handle in any exercise. By lowering the hips, grasp the barbell with palm toward the legs at shoulder width. Maintain a straight back while pulling the weight up, and straighten full and lean back slightly with the weight hanging across the thighs; lower the barbell to the floor and repeat three to five counts. Without setting the weight down, increase the action to the extent of pulling the barbell fully to the chest, but do not lift it overhead. Lower it again to a point below the knees and repeat the pull to the chest three to five times. Then, with the weight at the chest, push it overhead three to five times.

2. Curl. The barbell is grasped with palms away from the legs and raised to a position across the thighs as the exerciser stands erect. Then it is raised to the chest by flexing the arms, the barbell moving in an arc as the elbows remain at the sides. The exerciser should stand straight as possible throughout and endeavor to limit the action to the arms.

3. Press. Grasp the barbell with palms toward the legs and pull it to the upper chest. Then push it to fully locked arms overhead, lower to the chest, and repeat the overhead lift. The exerciser should stand straight throughout the performance of this exercise, leaning back only slightly to get the barbell past the face.

4. Rowing. With legs straight or very slightly bent, the exerciser leans forward and allows the barbell to hang just off the floor (Palms of the hands toward the legs). The position is one with the body parallel to the horizon, bending forward from the hips. Without any motion of the legs of body, the barbell is pulled up to

touch the chest at the bottom of the pectoral muscles. Then it is lowered and the movement repeated for the desired number of counts.

5. Squat. The barbell is placed on the shoulders at the back of the neck. The exerciser can lift it there himself as though pressing, or it can be placed across the shoulders by training partners, or it can be lifted from shoulder-high stands. The heels can be raised slightly on a board one or two inches thick for comfort. Keeping the back straight and chest high, the exerciser lowers into a full squat and rises, repeating for the desired number of counts.

6. Pullover. Lying supine, the barbell is grasped at shoulder width with arms stretched fully over (behind) the head. After inhaling fully it is pulled over to a position directly above the chest, exhaling as the weight rises in an arc. It is then lowered to the starting position with accompanying fully inhalation as it is lowered.

7. Rise-on-toes. The barbell is placed across the shoulders at the back of the neck, and the toes and balls of the feet are elevated on a 2-inch board, or higher, to allow the heels to extend below the level of support and stretch the muscles. The exerciser then rises fully on the toes, lowers, and repeats for the desired number of counts.

8. Dead Lift. With feet spaced comfortably apart, bend the knees, lower the hips, and lean forward to grasp the barbell. Then simply straighten fully until the barbell is resting across the thighs with the body erect and shoulders back. Lower and repeat.

9. Upright rowing. Hold a barbell (Palms toward the body) with a narrow hand spacing, at the hang position across the thighs. Then, keeping elbows higher than the barbell throughout the movement, pull it up along the abdomen and chest to the throat or chin. The legs and body should remain straight throughout the exercise.

10. Press on bench. To develop the muscles of the chest, as well as the triceps of the arms and the deltoids, one of the best exercises is to press a barbell from a point on the pectorals to locked arms over the chest while lying supine. The hands should be placed slightly wider than the breadth of the shoulders.

11. Bent-arm lateral raise, lying. The exerciser grasps a pair of dumbbells and lies supine on a bench. With arms slightly bent and held rigid, the weights are lowered, in arcs to each side, from a point directly over the chest. The lowering to full stretch of the pectorals muscles is accompanied by forceful inhalation. The dumbbells are then returned to the starting point in the same arc, with exhalation.

12. Lateral raise, standing. The exerciser should stand in a position of attention with dumbbells held at the sides, arms straight. Keeping the arms straight and knuckles up, the dumbbells are raised directly to the sides in a full semicircular arc until they are fully overhead. The arms should be kept rigid throughout.

The basic isometric exercises prescribed by Steinhaus and used in this study are as follows:

1. The elbow push. Stand with back to the wall--elbows at shoulder height and touching wall--hands at collar-bone level with palms down. Press elbows hard against the wall.

2. The hand push. Stand with palms touching and the elbows at shoulder height. Press palms together hard.

3. The Reach. Stand with left arm extended high over the head. Reach up as high as possible while keeping the heels on the floor. Repeat with right arm.

4. The muscle-maker. Stand with both elbows bent and the hands relaxed. Contract the biceps as hard as you can.

5. The twist. Stand with the arms extended, forward--fingers interlocked. Try to twist the arms inward. Repeat outward.

6. The grip. While standing, grip both hands as hard as possible.

7. The finger stretch. Stand with the arms stretched out in front and extend the fingers as hard as possible.

8. The front flattener. Lie on your back on the floor with hands on hips (elbows off the floor). Raise head and shoulders and the feet from the floor (Keep knees straight.)

9. The curver. Lie face down on the floor with hands on hips. Raise the head and shoulders and the feet from the floor. (Keep knees straight.)

10. The spread. Stand with the left side toward the wall. Press the left foot against the wall--keeping the leg straight. Repeat with right leg--right side toward wall.

11. The squat. Stand with hands on hips, knees bent, heels off floor.

12. The heel stand. Standing on heels, touching wall lightly for balance.

13. The arch raiser. Sit with the soles of the feet turned in toward each other and the toes curled under.

LEADERS

The subjects start at Station 1 and move from one test to the next. The testing is from the least to most strenuous. In general this order should not be reversed or the results will be unsatisfactory.

LUNG CAPACITY--Before each test, change the mouthpiece and lower the spirometer bell to the zero mark. The rubber plug at the base of the spirometer should be removed when lowering the bell, and then replaced again.

Give the signal for the subject to start, and then watch the indicated closely to note when it reaches the highest point. Record to the nearest cubic inch. Watch to see that the subject performs properly and that a second breath is not taken during the test. Test the subject at least twice. If any great discrepancy appears, retest again.

GRIP STRENGTH--Take the right-hand corner of the manuometer between the thumb and fore-finger of the right hand and place it dial down in the palm of the subject's hand while holding the hand to be tested with the left hand. Check the position of the manuometer to be sure it is correct. Watch carefully during the test to be certain the subject does not touch the body or any object with the hands. Test the subject twice for each grip and repeat if any great discrepancy appears. Record the best score to the nearest pound for each hand. Return the indicator to zero after each test.

BACK LIFT--Have the subject stand on the base of the dynamometer with feet close to the attachment and toes even with front edge of the base. Adjust the handle of the dynamometer so that when the subject is standing erect, his finger tips are just above the handle. When the subject is in the position to lift, the back should be slightly bent at the hips just enough so that he will not completely straighten when lifting. The legs should be straight with no bend at the knees. It is important not to bend the back too much, as the

resultant poor leverage is conducive to a poor lift as well as to the possibility of strain. With the back properly bent, however, there is little likelihood of injury from lifting.

Grasp the subjects hands firmly and give the signal to lift. During the lift, look to see that the subject is in the most advantageous position. An attempt to lift by standing on the toes indicates that the chain is too long. At the end of the lifting effort, the back should be almost straight. Any initial lateral sway should be checked immediately. Test the subject at least twice and repeat if any great discrepancy appears. Record the best lift to the nearest 5 pounds.

LEG LIFT--First adjust the belt and handle to the subject. Slip the loop of the belt over one end of the handle. With the handle in position at the junction of thighs and trunk, sling the belt around the back of the subject, placing it as low as possible over the hips and gluteal muscles. Then loop the free end of the belt around the other end of the bar, folding it back upon itself and tucking it in so that it rests next to the body. In this position, the belt will bind firm, and will not slip.

Then, have the subject take his position on the dynamometer base. Have him bend his knees enough so that when the chain is hooked to the handle the angle of the knees will be between 115 and 124 degrees. If a change of one link is too much, adjust by twisting the chain. Before instructing the subject to lift, be sure that the arms and back are straight, the head erect, one chest up. Give the signal to lift. If the subject begins to sway, steady him by grasping the knees firmly. Test the subject at least twice and repeat if any great discrepancy appears. Record the best lift to the nearest 5 pounds.

PULL-UPS--Observe the subject carefully as he performs the pull-ups to be sure that they are done properly. Count the number of pull-ups aloud. Indicate half-counts if the subject does not pull up all the way, if he does not straighten his arms completely when lowering the body, or if he kicks, jerks, or kips in performing the movement. Allow only four-half-counts, after which the subject should be stopped and his score taken at that point. Record the number of pull-ups.

PUSH-UPS--Adjust the bars to approximately shoulder height. Observe the subject carefully as he performs the push-ups to be sure that they are executed properly. Count the number of push-ups aloud. Count the jump to the front support position as one. At the first dip, gauge the proper distance the body should be lowered by observing the elbow angle. Then hold the fist so that the subject's shoulder just touches it on repeated push-ups. Indicate half-counts if the subject does not go down to the proper bent-arm angle or does not push up all the way to a straight-arm position. Allow only four half-counts, after which the subject should be stopped and his score taken at that point. Record the number of push-ups.

ORGANIZATION AND INSTRUCTIONS OF SUBJECTS

AGE, HEIGHT, AND WEIGHT--Age should be taken in years and months. Height and weight should be taken with the subjects in gymnasium uniforms, and recorded at the nearest half inch and pound, respectively.

LUNG CAPACITY--This item measures the amount of air that can be expelled from the lungs. Stand next to the spirometer with the end of the rubber hose in one hand. Take one or two deep breaths before the test. Then, after the fullest possible inhalation, put the mouthpiece into the mouth and exhale slowly and steadily while bending forward over the hose until all the air is expelled. Take care not to allow any air to escape either through the nose or around the edges of the mouthpiece.

GRIP STRENGTH--This item measures the strength of the hands. Place the manuometer in the palm of the right hand, dial down, so that the convex edge is between the first and second joints of the fingers and the rounded edge is against the base of the hand. The thumb should touch, or overlap, the first finger. Bend the elbow slightly and raise the arm backward and upward. Then swing the arm downward and forward in a sweeping arc and squeeze the manuometer with maximum force. Be certain the hands do not touch the body, or any object, while performing the test. Repeat the test using the left hand.

BACK LIFT--This item measures back strength. Stand erect in position on the base of the dynamometer, with the hands on the front of the thighs. When the chain has been properly adjusted, bend forward and grasp the handle firmly at the ends of the bar, with thumb clenching fingers and with one palm forward and one palm backward. Keep the head up and eyes straight ahead. At a signal from the leader, lift steadily with maximum force, keeping feet flat on the platform.

LEG LIFT--This item measures the strength of the legs. Hold the bar with both hands together in the center, both palms down, so that the bar rests at the junction of thighs and trunk. Maintain this position while the belt is fastened to the handle and adjusted to the body. Take position on the dynamometer platform with the feet close to the attachment and toes even with the front edge of the platform. At a signal

from the leader, exert a maximum force upward, extending the knees, being certain to keep the arms and back straight, the head erect, and the chest up.

PULL-UPS--This item measures the muscular strength and endurance of the arms and shoulders. Hang from the rings using any grip. Use the reverse grip when hanging from a bar. Chin as many times as possible. In executing the movement, pull up until the chin is even with the hands, then lower the body until the arms are straight. Do not kick, jerk, or use a kip motion. You will be penalized for each pull-up improperly executed.

PUSH-UPS--This item measures the muscular strength and endurance of the arms and shoulders. Stand at the end of the parallel bars, grasp one bar in each hand, and jump to the from support position with arms straight. Execute the push-up as many times as possible. In performing this movement, lower the body until the angle of the upper arm and forearm is less than a right angle. Then push-up to the straight-arm position. Do not jerk or kick. You will be penalized for each push-up improperly executed.

APPENDIX B

FIGURE 1

FORM A - ORDER FOR TESTING ROGER'S STRENGTH TEST

5	6	7
Pull-Ups	Push-Ups	Scoring Table

Arm Strength Formula: Pull-ups + Push-ups x $\left(\frac{w}{10} + H - 10\right)$

4

Example: $10 + 12 \times \left(\frac{160}{70} + 69 - 60\right) = 361$

Back & Leg Strength Test

Strength Index: Add together the scores on each item. (Lung capacity, right grip, left grip, back and leg strength, and arm strength)

Normal Strength Index: Tables on pp. 42-45 Weiss & Phillips. (100 is considered an average score)

Physical Fitness Index: $P.F.I. = \frac{\text{Achieved SI} \times 100}{\text{Normal SI}}$

3	2	1
Grip Strength Test	Lung Capacity Test	Vital Statistics

FIGURE 2

SCORE SHEET

A - Change
B - % Change

Name _____

Test No.	1	2		3	
Date					
Age					
Weight					
Height					
Multiplier					
Pull-Ups					A B
Push-Ups					
Arm Strength					
Change					
% Change					
Leg Lift					A B
Back Lift					
Right & Left Grip					
Lung Capacity					
Strength Index					
Change					
% Change					
Normal Strength Index					
P. F. I.					